CONCERNING THE INTRODUCTION INTO THE UNITED STATES OF EXTRA-LIMITAL WOOD-DESTROYING FUNGI

James R. Weir

Introduction

A recent study of a number of tropical wood-destroying fungi which grow on species of trees, the wood of which, either in a manufactured or unmanufactured state, is imported into the United States, raises a question which may well receive attention from foresters and dealers in structural timbers. Our plant quarantine laws provide for a close scrutiny of a great variety of plant material, but no. one has given much thought to the possibility of the introduction into this country of wood-destroying fungi on imported timbers.

That fungi may be transmitted to distant parts of the country by the living mycelium in the wood of structural timber in initial stages of decay, is well known. A few examples in the writer's experience are illuminating. At Portland, Oregon, on a white oak timber which had come originally from Ohio, the sporophores of *Stereum frustulosum* Fr. were found. This fungus has never been reported from the West, and in this case was certainly carried in the diseased timber. It could be easily introduced into western hardwood forests by this means. At Bellingham, Washington, in August, 1916, two species of wood-destroying fungi not native to this country were collected from old timbers stacked on the harbor wharves. The timbers were practically rotted and evidently had been used in temporary structure work in vessels. These two species, viz., *Polystictus Persoonii* Fr. and *Trametes atypus* Lév. (*T. aurora* Ces., *T. paleacea*), are common in all tropical and semi-tropical countries, especially in Japan and the Philippines. Several collections of the latter species from the Philippines, in the writer's herbarium, show that it grows on some

of the most valuable timber trees of that region, and evidently causes a serious rot. It has also been observed that in one case square timbers showed incipient or initial decay by fungi not known to occur in the foreign country to which the timbers were shipped. The ease with which lumber may become infected, while stored in insanitary yards, is only another example of how wood-destroying fungi may be transported from one country to another.

DISTRIBUTION OF WOOD-DESTROYING FUNGI

In contrast to the higher plants, many of the wood-destroying fungi are widely distributed throughout the world. For example, *Fontes annosus* Fr., *Fomes* (*Trametes*) *Pini* (Brot.) Lloyd, and *Armillaria mellea* (Vahl.), three of the most destructive forest tree fungi in America and Europe, are reported from various tropical countries. In the latter regions these species are apparently not abundant, a condition which is difficult to explain. On the other hand, there are a number of serious wood-destroyers and parasitic species which are confined to the tropics or to foreign countries in general. There is no reason why these species should not find a favorable environment in some of the varied climates of the United States, if once introduced. It is well known that in the case of some parasitic fungi a change from one country to another of different climatic conditions may often be favorable to the fungus, which may develop into a serious pest. This could be true of many foreign wood-destroying fungi.

POSSIBLE EXPLANATIONS FOR THE APPARENT SMALL NUMBER OF WOOD-DESTROYING FUNGI IN THE TROPICS

Contrary to the general opinion and as compared to the conditions in the temperate zones, the number of species of this group in the tropics may not be considered particularly abundant. Westerdijk[1] explains this condition through the assumption that in the tropics "the heavy rainfalls, combined with the abundant transpiration—owing to the intense heat, must cause a high water-

[1] Westerdijk, Johanna. Phytopathology in the Tropics. Ann. Mo. Bot. Gard. 2: 308. 1915.

content and a small air-content, of the wood-vessels of the trees, thereby making a substratum poor in air. . . ."

The assumption that an abundant transpiration may cause a high water content in the tissues is in direct contradiction to the latest research on the subject. Dixon[2] demonstrated that the transpiration pull during the growing season tends to reduce the water content of the plant, hence the gas content is increased. That the gas content in the wood is an important factor influencing the entrance of the mycelium and its subsequent spread has been experimentally determined by Münch.[3] More recently Zeller[4] showed that any factor influencing the proportion of water and air in the substratum is of great importance.

A factor which would apparently retard the development of wood-destroying fungi in the wood-vessels of trees growing in the tropics is the absence of any marked periodicity in wood formation. Naturally the vital processes in tropical vegetation have a rhythmical alternation of periods of rest and activity, determined usually by a wet and dry season, but the latter period is short and no such contrast between large and small vessels is produced as in temperate zones. This condition of almost continuous growth in contrast to the alternating periods of rest and growth in colder climates may tend to retard the spread of mycelium in the wood. This is reasonable to suppose, in view of the fact that in the temperate zone wood-destroying fungi are more active during the dormant period of their hosts. Continuous growth, or unimportant temperate changes, may either one conceivably result in decreased air content, and the mycelium would have difficulty in finding the proper balance between air and moisture in the wood. The great density of most tropical woods would also be a factor in this respect. Again, it is conceivable that the soil solutions in the tropics, being warmer and therefore less able to hold gas in solution, contain less oxygen than in tem-

[2] Dixon, H. H. Transpiration and the ascent of sap in plants. Macmillan & Co. 1914.

[3] Münch, E. Untersuchungen über Immunität und Krankheitsempfänglichkeit der Holspflanzen. Naturwiss. Zeitschr. f. Forst. u. Landw. **7**: 54–75, 87–114, 129–160. 1909.

[4] Zeller, S. M. Studies in the physiology of the fungi. II. *Lenzites saepiaria* Fr., with special reference to enzyme activity. Ann. of Mo. Bot. Gard. **3**: 448–449. 1916.

perate regions. This high temperature and consequent low gas solubility, resulting in a deficiency of dissolved oxygen in soil solutions and therefore in cell sap, might make tropical wood less aërated. Abundant decaying organic matter resulting in a soil solution with a low oxygen and a high carbon dioxide content might possibly produce a cell sap with the same unfavorable gas content. There is also a possibility of the heartwood of trees remaining functional for a longer period than is the case in temperate zones. This would reduce the gas content and prevent the advance of the mycelium in the wood. This condition is analogous to the observed behavior of mycelia of wood-destroying fungi in the wood of resinous and non-resinous conifers, or in the wood of broad-leaved species forming or not forming heartwood. In trees with a pronounced heartwood, decay is usually very pronounced, in contrast to those where the central cylinder remains for a longer time functional; that is, transporting soil solutions to the crown. There are exceptions to this generalization. The heartwood of birch, which remains functional for a longer time than that of oak, is seriously rotted by *Fomes ignarius* (Gill). The non-resinous heartwood of *Abies grandis* is uniformly rotted by *Echinodontium tinctorium* E. and E. Undoubtedly the requirements of fungi differ to the extent that whereas one species may find the non-resinous heartwood of *Abies,* for example, favorable, as in the case of *Echinodontium,* the fungus will not develop in the wood of pine or larch. In the case of *Abies* and *Echinodontium* we may assume that the gas present in the heartwood of the host may be of a higher oxygen ratio than is the case in those trees which it will not attack. To understand the particular conditions which govern the relations of host and fungus is a problem for the future, and is of great practical importance.

TROPICAL WOOD-DESTROYING FUNGI IN THE TEMPERATE ZONE

The reason for contrasting the conditions of growth between the tropics and temperate zones is by way of introduction to the idea that the wound fungi[5] of tropical or foreign timber trees

[5] In the writer's opinion the term "wound parasite" as it is ordinarily employed is misleading. The parasitism of but few wood-destroying fungi

would find favorable conditions for growth on our native species. It is to be assumed, of course, that our native forest trees, at least in some regions, would be susceptible to attack. It may also be assumed that the tropical fungi have built up strong parasitic tendencies in order to counteract continuous growth in their exogenous and endogenous growing hosts, which would tend to make them more vigorous and destructive when growing under reverse conditions. Of course, all of this is pure conjecture, for our knowledge as to how fungi endemic in tropical and foreign countries would react to the low temperature of a more temperate climate, is very limited. Unless their food requirements are at variance with that which they would find in our native trees, the lower temperature can be expected to stimulate growth. The average temperature for the growth of wood-destroying fungi is comparatively low. Falck[6] has shown that the growth range for a number of wood-destroying fungi lies between 3° and 44° C., with an optimum temperature between 18° and 35° C. Humphrey[7] states that "for the majority of species the most favorable temperature lies between 75° and 85° F." This author further states that out of a series of some 50 species tested none would grow above 118° F., and in general wood-destroying fungi are much less tolerant of high temperatures than low ones, while temperatures slightly above the freezing point will usually permit some growth. This writer found that on storing a large number of stock cultures of different species in an ice box where the

has been investigated. The mere fact that they are found growing from wounds does not imply that they would attack the living cell. *Fomes pinicola,* one of the most common saprophytes, chiefly on coniferous wood, not infrequently enters through wounds and destroys the heartwood of living trees, but it would not be considered parasitic. Some such term as *wound fungus* would be more conservative, and would merely imply that the fungus grew on the dead wood of wounds or entered the heartwood in this manner.

6 Falck, Richard. Wachstumgesetze, Wachstumfaktoren und Temperaturwerte der hölzzerstörenden Mycelien. In Moller, Alfred. Hausschwammforschungen. Heft 1, p. 53–154. 1907.

——. Die Lenzitesfäule des Coniferenholzes, eine auf kultureller Grundlage bearbeitete Monographie der Coniferenholz bewohnenden Lenzites-Arten. In Möller, Alfred. Hausschwammforschungen. Heft 3, 234 pp. 24 fig., 7 pl. 1909.

7 Humphrey. Timber decay and its growing importance. Railway Age Gazette, p. 10. Dec. 15, 1916.

temperatures vary around 40° to 60° F., several species grew luxuriantly. It is known that the coldest weather in northern climates is not sufficient to destroy the vitality of sporophores of tree fungi, in fact Buller[8] has shown that certain species will withstand the temperature of liquid air (— 190 deg.) for protracted periods. Westerdijk[9] advances the view that the tropical temperature is too high for many fungi, and states that in her laboratory over 600 fungi are cultivated, and this collection shows cleary that the temperature of optimum growth of the greater part of the fungi lies below 30° C., often under 25° C. An exposure to high temperature prevents many parasites from forming their spores or fruiting bodies, whereas others require a change of temperature for normal growth. The Polyporaceae, for instance, bear exposure to frost very well, but many of them scarcely develop at 30° C. That the low winter temperatures of northern climates will not affect the vitality of at least some tropical wood-destroying fungi is shown by the following experiment. During the winter of 1909, the writer took a section of a tree branch on which were two or three small sporophores of *Polystictus sanguineus* Fr. from the mycological collection at the University of Munich, and placed it on the ground in the forest among other branches of native Alnus bearing sporophores of *Polystictus hirsutus* Fr. The branch had been in the collection about two years and had been collected in the low lands of Brazil. Very early in the following spring, while snow was still on the ground, the sporophores of the native fungus started growing. A week later the tripical species revived, and before the end of spring not only had produced a new hymenium but enlarged its hymenial surface to about one fourth of its original size, and one entirely new but small sporophore was produced. Sporophores of *Polystictus occidentalis* (Klotzsch) and *P. maxima* (Mont.) from the warm zones of Cuba attached to their substrata were exposed to

8 Buller. Upon the vitality by dried fruiting bodies of certain Hymenomycetes, including an account of an experiment with liquid air. Trans. of the British Mycological Society, 112. 1912.

Also Buller and Cameron. On the temporary suspension of vitality in the fruit bodies of certain Hymenomycetes. Trans. of the Royal Soc. of Canada. Third Ser. **6**: 73–75. 1912.

9 Westerdijk, Johanna. Loc. cit. 1.

the winter weather of Missoula, Mont. (—30° Fahr.). In late spring these plants revived and produced new fertile spore surfaces. These experiments not only illustrate the xerophytic nature of the group[10] to which they belong, but demonstrate the fact that at least some tropical wood-destroying fungi will, no doubt, find suitable conditions of growth in regions farther north. It may be expected, of course, that the change in environment will affect certain morphological changes in the fruiting structure. Indeed the question may be asked, why not regard *Polystictus sanguineus* identical with *P. cinnabarinus* Jacq. This response to change in environment may be observed in any of our native species in its range from warmer and drier regions to the damp cold forests of the north, or when observed at different elevations on high mountains.[11]

As already indicated, there is always the danger of a fungus, irrespective of the part of the world from which it may come, finding a more favorable environment when introduced into new regions. The history of many of our plant disease epidemics in this country during the past few years illustrates this fully. It is possible that certain of our common wound fungi may have developed parasitic tendencies due to great difficulties to be overcome, as has previously been indicated, and may be of some economic importance in this country. For example, *Fomes applanatus* Pers., found in the heartwood of a variety of trees, is not known to be a parasite in this country. The writer has specimens of this fungus from Peru, with the statement that it attacks the roots of fruit trees and does considerable damage. This would lead one to think that it would be unsafe to introduce this particular strain (if it may be so called) or this species into this country.

Not until investigations in forest pathology in tropical lands have reached as high a plane as they have in temperate zones will we know what we may fall heir to from foreign countries. With the increase in commercial intercourse with foreign lands and the increased demands for the timbers and other plant life they pro-

10 Buller. Loc. cit. 8.

11 Weir, Jas. R. Notes on the altitudinal range of forest fungi. MYCOLOGIA, 10: p. 4–14. 1918.

duce, it is reasonable to suppose that we may expect wood-destroying fungi to find their way into this country. It would seem a wise plan to make a careful study of the agents of decay directly in the field where they grow. This would yield a knowledge of the fungous diseases in the uncultivated forests of exporting countries, and our inspectors could then do their work more intelligently.

OFFICE OF INVESTIGATIONS IN FOREST PATHOLOGY,
BUREAU OF PLANT INDUSTRY,
SPOKANE, WASHINGTON.